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ABSTRACTS OF PAPERS

Twentieth Annual Albert L. Tester Memorial Symposium, 27–28 April 1995[1]

The Albert L. Tester Memorial Symposium is held in honor of Professor Albert L. Tester, who, at the time of his death in 1974, was senior professor of zoology at the University of Hawai'i at Mānoa. The faculty and students of the Department of Zoology proposed an annual symposium of student research papers as a means of honoring, in a continuing and active way, Dr. Tester's lively encouragement of student research in a broad range of fields in biology. Papers reporting original research in any aspect of biology solicited from graduate students at the university are presented at the spring-semester symposium. Income from contributions to the Albert L. Tester Memorial Fund of the University of Hawai'i Foundation provides two prizes for the best papers. Judges include representatives of the Department of Zoology faculty, winners from the preceding symposium, and a distinguished scholar from another university who also presents a major symposium address. This year Mimi A. R. Koehl, Professor of Integrative Biology, University of California at Berkeley, participated in the symposium.

Isolation and Characterization of *Scytonema ocellatum* Extracellular Nuclease

JASON E. ADOLF[2]

The blue-green alga (Cyanobacterium) *Scytonema ocellatum* strain FF-66-3 produces tolytoxin, a natural product belonging to the scytophycin class of compounds with potential use as an anti-cancer drug. Preliminary attempts at molecular genetic analysis of this strain were hindered by presence of a potent extracellular nuclease activity. This report is concerned with the isolation and characterization of this nuclease activity to evaluate inhibitors and produce a nuclease-free, genetically transformable strain. Nuclease activity was recoverable from both the culture supernatants and cell-free extracts of axenic cultures. Cell-free extracts and culture supernatants were capable of degrading linear as well as covalently closed circular DNA without any evidence of generation of restriction patterns that would suggest site specificity. A facile purification scheme based on ammonium sulfate precipitation, gel-filtration chromatography, affinity chromatography, and HPLC was developed and used to prepare enzyme for sequence analysis. Yield and enzyme homogeneity were estimated by a combination of electrophoretic and chromatographic techniques.

[1] Manuscripts accepted 15 June 1995.
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Major Histocompatability Complex Diversity in the Hawaiian Monk Seal

PAUL ARMSTRONG[3]

The Hawaiian archipelago is inhabited by the most endangered seal in U.S. waters, the Hawaiian monk seal (*Monachus schauinslandi*). Genetic problems particular to small or endangered populations include decreases in genetic variability, with a concomitant loss of evolutionary potential, and inbreeding depression. DNA sequence analysis of the mitochondrial control region and nuclear introns from two tubulin genes revealed that Hawaiian monk seals have the lowest levels of genetic diversity found in any natural populations of mammals. Loss of genetic variability can affect important functional loci such as the major histocompatability complex (MHC). The MHC is normally highly variable in mammals and it is the complex of genes responsible for antigenic responses; however, small populations may show significant loss of MHC polymorphisms because of genetic bottlenecks. Decreased variability at MHC loci has been suggested to result in greatly increased susceptibility to population extinction by disease. To assess genetic variation in the MHC of Hawaiian monk seals, DNA sequences from the *DQA* gene, a class II gene of the MHC, were examined. No DNA sequence variation was found in Hawaiian monk seals across their geographic range. These data may indicate a susceptibility to disease in Hawaiian monk seals. The relationship between conservation, disease, and MHC diversity is important when designing conservation strategies and if Hawaiian monk seals can be shown to be susceptible to disease because of low MHC variation, conservation strategies could be adopted to decrease the possibility of this type of disaster.

Gastric Evacuation in Juvenile Scalloped Hammerhead Sharks, *Sphyrna lewini*

AARON BUSH[4]

Gastric evacuation was studied in juvenile scalloped hammerhead sharks (*Sphyrna lewini*) in Kāne'ohe Bay, O'ahu, Hawai'i. The goal of this study was to quantify the rate at which food was emptied from the stomach to facilitate estimation of daily ration of juvenile scalloped hammerheads in Kāne'ohe Bay. Sharks were caught with handlines and kept in field enclosures. Experimental meals consisted of 1.2% (dry weight herring/wet weight shark) of goldspot herring (*Herklotsichthys quadrimaculatus*), and stomach contents were recovered by gastric eversion. Fifty-six percent of the meal was digested in 10 hr ($n = 4$), 73% in 20 hr ($n = 4$), and 94.5% was digested in 30 hr ($n = 2$). Water temperatures during the experiment ranged from 22.0 to 24.5°C. These preliminary data indicate that the rate of gastric evacuation in juvenile scalloped hammerheads is similar to the rate of digestion of juvenile lemon sharks.

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Occurrence of the Hawaiian Hoary Bat in Koa/'Ōhi'a Montane Wet Forest on the Island of Hawai'i[5]

THERESA A. CABRERA[6]

The endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) has been reported from a wide variety of native and non-native habitat types, though it is more often associated with native vegetation. Koa/'Ōhi'a (*Acacia/Metrosideros*) Montane Wet Forest, such as that occurring at Hakalau Forest National Wildlife Refuge on the island of Hawai'i, is one type of native community in which the bat has been observed. Hakalau is regarded as a high-density area for several species of native, insectivorous forest birds, and it may provide essential habitat to the bat as well. As an aerial insectivore, the Hawaiian hoary bat depends on a broad prey base of volant insects that predominantly includes moths (Lepidoptera) and beetles (Coleoptera). A past study at the refuge revealed that moths are the second most abundant arthropod taxon (after spiders). During the summer of 1994, I conducted a survey for the Hawaiian hoary bat to gather baseline data on the occurrence of bats at Hakalau. Bat activity was monitored with an echolocation sensing device. Thirteen sites within and adjacent to the refuge were monitored on 15 nights between 25 June and 17 August 1994. Bats were detected on 9 nights at six sites. Bat activity was greatest in Koa/'Ōhi'a Montane Wet Forest in the Maulua Tract of the refuge. The occurrence of the bat in different portions of the refuge during June, July, and August suggests that the refuge may be important at least as breeding habitat.

Sedimentary Relationships and Community Structure of Macrofaunal Assemblages in Reef-Associated Sediments at Hanalei Bay, Kaua'i[7]

RALPH C. DEFELICE[8]

In this study, the organization of benthic invertebrate communities in sediments adjacent to reef tracts was investigated and their relationship with sediment variables was examined. Benthic samples were taken from Hanalei Bay, Kaua'i, in July–August 1994 by a diver-held corer. The five cores from each site were washed through a 500-μm sieve and the fauna sorted to the family level. Forty-eight families (15 polychaete, 19 crustacean, 10 mollusc, and 4 other) and ca. 3200 individuals were collected from the eight sampling sites. Sites were classified on the basis of benthic assemblages and sediment characteristics. Cluster analysis grouped the coarse and medium-sized sediment sites and isolated a single fine-sediment site. Sediments of similar type supported broadly similar infaunal communities, but no significant correlation between abundance, diversity, or taxonomic richness and median grain size was apparent. Although community organization appears to be generally similar, abundance of individuals, diversity, and richness seem lower than those reported from comparable sediments in other tropical reef habitats.

[5] Supported by a grant from the Hawai'i Natural Area Reserve System to L. Freed.

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Tobacco Glutamate Decarboxylase is a Calmodulin-Binding Heat Shock Protein

NIHAL DHARMASIRI, SERAFIN COLOMANARES, AND H. M. HARRINGTON[9]

Calmodulin (CaM), a ubiquitous eukaryotic protein, modulates activity of many enzymes in response to changes in Ca^{2+} level. Unlike in animal systems, to date, only a few CaM-regulated enzymes have been characterized from plants. Glutamate decarboxylase (GAD), a CaM-regulated enzyme, catalyzes conversion of glutamic acid to γ-aminobutaric acid, which accumulates in plant tissues under stress conditions. Here we report characterization of a calmodulin-binding GAD cDNA from cultured tobacco cells (*Nicotiana tabacum* Wisconsin 38). A cDNA clone, isolated by screening a tobacco expression library with ^{35}S-labeled CaM, was sequenced. The 1.2-kb cDNA insert contained an open reading frame of 909 bases and 290 bases of 3′ untranslated region. The deduced amino acid sequence of this cDNA has more than 91% similarity (85% identity) to other plant GADs and has lesser similarity to bacterial and animal counterparts. The secondary structure prediction of the amino acid sequence showed presence of a basic amphiphilic-helix from amino acid residues 208 to 229, suggesting that it may be the CaM binding domain. A probe made from the cDNA insert recognized a single band of 2.1 kb in northern analysis. The basal level of GAD mRNA increased to a maximum within 15 min of heat shock treatment at 38°C and subsequently declined to prestress level over a 2-hr period. These results indicate that GAD expression is regulated by heat shock and suggest a role for GAD in heat shock response.

Evolution of Diet in *Conus*

THOMAS F. DUDA, JR.[10]

The origins of unique traits or modes of life are important events in the evolution and diversification of species. The characteristics of an organism that permit or drive it to enter a new ecological or adaptive space are largely unknown. *Conus* is a genus of several hundred species of predatory marine gastropods with three main feeding types: piscivory, molluscivory, and vermivory. The latter is the most common and probably the primitive type. Cones rely upon a venom delivery apparatus modified from the radula and venom made of a variety of toxic peptides to paralyze their prey. Preliminary analyses suggest that venoms from species of the different feeding types are prey-specific. Do derived feeding types represent monophyletic groups or have these evolved many times? I used molecular techniques to investigate the evolutionary origins of piscivory and molluscivory in *Conus*. A phylogeny derived from mitochondrial 16s sequences suggests that both feeding types arose early in the evolutionary history of this genus. It appears that piscivory evolved more than once; however, it is difficult to either support or disprove the hypothesis of monophyly of the molluscivorous species because of lack of resolution of the deep lineages. Evolution of piscivory in gastropods has only occurred once, in *Conus*; the fact that this condition arose several times within this genus may provide evidence for the "pre-adaptation" of *Conus* for this mode of feeding.

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Sodium-Proton Exchange in the Atlantic Lobster[11]

JEFFREY M. DUERR[12]

Characterization of Na^+/H^+ exchange in basolateral membranes of lobster (*Homarus americanus*) hepatopancreas was performed utilizing basolateral membrane vesicles (BLMV) purified using a PERCOLL density gradient technique. Purity of isolated BLMV was ascertained by measuring enrichment of Na^+-K^+ ATPase (13.1-fold) and alkaline phosphatase (1.2-fold). Amiloride-sensitive Na^+/H^+ exchange was demonstrated. Unlike the observed electrogenic $2Na^+/1H^+$ exchange on the apical membrane from the same tissue, kinetic studies of Na^+ transport by BLMV indicate an electroneutral antiport with a $K_m = 16.12 \pm 1.79$ mM and a $J_{max} = 611 \pm 22.7$ nmol/mg/min. Amiloride acted at a single binding site by mixed inhibition ($K_i = 108$ μM), and external Li^+ was shown to be an effective competitive inhibitor of the exchange process ($K_i = 493$ μM). Transport was not inhibited by a monoclonal antibody generated against protein elements of the apical $2Na^+/1H^+$ exchanger. Presence of a membrane-potential sensitive, Na^+-accepting ion channel was also demonstrated. The lobster hepatopancreatic basolateral membrane Na^+/H^+ exchanger physiologically resembles members of the NHE family of Na^+/H^+ antiporters described in vertebrates and departs from the apical electrogenic system previously described for lobster. The possibility that the basolateral Na^+/H^+ antiporter is an NHE isoform has yet to be verified.

Movement and Early Survivorship of Juvenile Coral Reef Fishes on Artificial Patch Reefs[13]

JENNIFER L. FREDERICK[14]

There is increasing interest among marine ecologists in determining the nature of postsettlement losses of coral reef fishes and the value of postlarvae as predictors of the distribution and abundance of adult populations. This study distinguished migration as an important postsettlement phenomenon that affects estimates of early survivorship rates of juvenile coral reef fishes. Individuals settling onto artificial patch habitats were collected, marked, released, and tracked over an isolated system of artificial patch habitats. Movement and survival of marked juveniles were monitored by visual census. Some recently settled juvenile fishes moved as much as 100 m over open sand. Survivorship rates calculated from observations of uniquely marked individuals were contrasted with survivorship rates estimated by comparing the initial number of newly settled individuals at a site with the number of individuals there after a given time interval. Comparison revealed that new settlers and immigrants can mask the loss of individuals included in the original census and inflate survivorship. Survivorship can also be underestimated when new settlers subsequently emigrate and survive at another site, but are unwittingly recorded as lost because of mortality.

[11] Supported by NSF grant IBN 93-17230.

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[13] This work was funded by the Hawai'i Cooperative Fishery Research Unit through a grant to J. Parrish by the Hawai'i Department of Land and Natural Resources, Division of Aquatic Resources, MHI-MRI.

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Spatial and Temporal Dynamics within a Hawaiian Forest Bird-Arthropod Community[15]

SCOTT FRETZ[16]

Hawaiian forest canopy arthropods are likely to have a major influence on the avian community for which they serve as prey. In this study the relationship between spatial and temporal population and community dynamics of two Hawaiian forest bird species and their arthropod prey was explored. Previous work suggested that the birds rely heavily on spiders and caterpillars associated with the upper canopy levels of the dominant rain forest canopy tree species, ʻōhiʻa (*Metrosideros polymorpha*). Abundance of these taxa was estimated by sampling vegetation from the ʻōhiʻa canopy. Sampling was carried out at two sites that differed greatly in the abundance of two avian predators and was carried out in three discrete time periods representative of the birds' reproductive cycles, and hence abundance. The site with low bird abundance showed high variability in spider abundance, but no difference in caterpillar abundance. Between time periods, the site where the birds are common showed no difference in spider and caterpillar abundance, but the site in which the birds are rare showed a peak in spider abundance corresponding to the fledging period of the avian predators. These findings suggest that the avian reproductive cycle is adapted to exploit seasonal peaks in prey abundance and that avian predators depress prey populations where they are common.

Seasonal Variation in a Coral Reef Fish Assemblage on an Exposed Shoreline[17]

ALAN M. FRIEDLANDER[18]

Patterns and processes that govern coral reef fish assemblages have usually been examined in stable, low-latitude locations. Environmental conditions on high-latitude reefs can be extremely variable and may structure fish assemblages in ways not previously observed in more stable surroundings. In an attempt to examine temporal changes in assemblage structure, an intensive study was conducted on the reef fishes of Hanalei Bay, Kauaʻi, from 1992 to 1994. Hanalei Bay is directly exposed to winter swells and can experience surf heights in the 5- to 10-m range during that time of year. Heavy rainfall and high river discharge are also frequent during that season. Twenty-two transects (25 by 5 m) were established in a wide variety of habitats and censused monthly over the 2-yr period ($n = 1052$ censuses). Over 121,000 sightings of individuals from 150 species were surveyed during the study. Seasonal patterns in number of species, number of individuals, and species diversity were observed, with winter values being lower than those in other seasons. These ensemble properties were higher at deeper sites and those sites with greater habitat complexity. Surf height and degree of wave exposure were negatively correlated with several measures of assemblage organization. These seasonal changes may suggest some type of short-range movement from more exposed and monotypic habitats to deeper locations that provide refuge from high-energy wave action during the winter.

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[17] This study was funded by Hawaiʻi Department of Land and Natural Resources, Division of Aquatic Resources, MHI-MRI project grant to J. Parrish.

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Adventures of a Scatologist: A Study of the Diet of the Hawaiian Monk Seal, *Monachus shauinslandi*[19]

GWEN GOODMAN-LOWE[20]

The Hawaiian monk seal is currently considered the most endangered pinniped found in U.S. waters, yet little is known about its diet. Prey composition of the Hawaiian monk seal was studied from 927 scat and spew samples collected in the Northwestern Hawaiian Islands from 1991 to 1994. Prey items were identified from fish scales, bones, and otoliths, and from cephalopod beaks and crustacean exoskeletons. Diet was compared among the 4 yr, the five main breeding islands, and among adult males, adult females, and juveniles. Reef fish families occurred in ca. 92% of the scats and spews, followed by octopi (~30%), squid (~5%), and crustaceans (~10%). Of the 28 families of reef fishes that were represented in the samples, Labridae, Balistidae, Holocentridae, and Congridae occurred most frequently. The presence of squid and some deepwater fishes reveals that monk seals are foraging over the bathypelagic zone in addition to within epibenthic reef habitats. Samples examined contained both nocturnally and diurnally active fauna, indicating that seals may be feeding during either the day or night. Analysis of the data suggests that diet diversity does not vary greatly among years, islands, or age/sex classes, possibly indicating that starvation of seals at certain islands may be caused, in part, by a lowered prey abundance rather than a reduced prey diversity.

Mixed-Species Flocking in Endangered Hawaiian Honeycreepers[21]

PATRICK J. HART[22]

When a large-scale reduction in population size occurs in social species, a loss or modification of important social behaviors may follow. The endangered Hawai'i 'ākepa, *Loxops coccineus coccineus*, varies considerably in density throughout its remaining range. This study took advantage of a natural situation in which two nearly adjacent 1-km^2 tracts of forest are geographically, elevationally, and botanically indistinguishable, yet one site contains densities of 'ākepa at least three times greater than the other. At both sites, 'ākepa take part in mixed-species, post-breeding flocks that can last up to 4 months. These flocks seem to exist primarily in the context of feeding fledglings and protecting them from the 'io, *Buteo solitarius*, their main avian predator. Flocking dynamics was compared between sites to determine how reduced population size affects this social behavior. The number of flocks encountered per distance surveyed was recorded to estimate density of flocks within each study site. Flock size was determined by counting birds as they moved between trees. Flock composition was estimated through sightings and vocalizations. There was no difference in the number of flocks between sites, but mean flock size was greater at the high-density area. The number of 'ākepa within flocks varied disproportionately to their density at each site. It appears that 'ākepa are creating higher-density flocks through increased movement from surrounding areas at the low-density site.

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[21] Supported by a MacArthur Foundation Grant to L. Freed, R. Cann, and S. Conant.

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Distribution of UV-Absorbing Mycosporine-Like Amino Acids in Tissues of Hawaiian Corals: A Depth Profile[23]

ILSA B. KUFFNER,[24] M. E. ONDURSEK,[25] AND M. P. LESSER[26]

Tissues of five species of Hawaiian hermatypic corals were found to contain concentrations of mycosporine-like amino acids (MAAs) inversely correlated to depth and dose of UV radiation. Four of the six depth profiles conducted resulted in highly significant linear relationships between MAA concentration and UV radiation level. *Montipora verrucosa*, *Montipora patula*, *Porites compressa*, *Pocillopora damicornis*, and *Pocillopora meandrina* were collected at a series of depths in and outside of Kāne'ohe Bay, O'ahu, Hawai'i, and analyzed using HPLC to identify and quantify the UV-absorbing compounds. Eight known and two unknown compounds with absorption maxima ranging from 313 to 360 nm were separated and quantified. Spectroradiometric measurements were made simultaneously during sampling to quantify and analyze the light regime at the collection sites.

Proximate Function of Subadult Plumage in the Hawai'i 'Ākepa: Results of Model Playback Experiments[27]

JAAN KAIMANU LEPSON[28]

Many sexually dichromatic birds undergo delayed plumage maturation, wherein young males spend their first potential breeding season in a duller subadult plumage, even though those males are usually sexually mature. The status-signaling hypothesis has been proposed to account for subadult plumage by enabling young males to signal a subordinate status and thereby incur less aggression from older males. I tested the status-signaling hypothesis in the Hawai'i 'ākepa (*Loxops coccineus coccineus*), which has a 2-yr delayed plumage maturation. Second-year males resemble adult females and third-year males are intermediate between them and adult males. I performed playbacks of songs and displays with plastic models of adult female, adult male, and the two subadult male plumages to determine how adult males and females respond to these different plumage types during competitive and noncompetitive seasons. Adult males had more intense responses and approached the models significantly closer during the competitive season, and showed a significant linear response to model brightness for closest approach and change in distance, but not for reaction time. Females responded significantly more intensely to adult male models than to female or second-year subadults, with third-year subadults intermediate. These are the first such experiments with a nonterritorial species and support the status-signaling hypothesis.

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[27] Funded by a grant from the John D. and Catherine T. MacArthur Foundation (to R. L. Cann, S. Conant, and L. A. Freed).

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Rotenone as a Tool for Ecological Experiments

KEN LONGENECKER[29]

For 83 yr, biologists have used rotenone to collect fish or reduce their populations, yet little attention has been given to effects of rotenone on nontarget aquatic species, specifically coral reef organisms. I used a controlled field experiment to assess rotenone's effects on mortality of eight coral species commonly found on Kāne'ohe Bay's fore reef. *Pavona duerdeni* was the only coral significantly affected. Field observations and a literature review suggest that other invertebrates, especially arthropods, suffer high mortality when exposed to rotenone. This information should be of interest to coral reef managers, but these results are more valuable in identifying rotenone as an experimental tool. As a specific example, reef fish ecologists can use its selective toxicity to create open patches in the coral reef, without changing habitat structure. The effect of a species on community composition can be assessed by its reintroduction. If invertebrates are important to the system under study (e.g., a prey resource), their initial elimination would control for the effects that prey variability may have on subsequent recruitment. Understanding rotenone's effects on other organisms may identify unique ways to address current ecological questions. For instance, its historical use as an animal and agricultural insecticide suggests that rotenone may be a valuable tool to terrestrial ecologists.

Artificial Hybridization in the Hawaiian Endemic Genus *Labordia* (Loganiaceae)

TIMOTHY J. MOTLEY[30]

Crosses were performed within and between eight species of *Labordia* and one Guamanian species of the closely related genus *Geniostoma*. The *Labordia* populations were from O'ahu, Moloka'i, and Hawai'i, and the intraisland populations were geographically isolated. Selfing of *Labordia* individuals was not possible because the genus appears to be functionally dioecious, with plants lacking either ovules or pollen grains. Inflorescences bagged to prevent pollination before anthesis never produced seed, but crosses performed between individuals within the population almost always (>90%) produced viable seed. Interspecific crosses between species on different islands, in separate taxonomic sections of the genus, and from variable ecological habitats, in most cases, produced high seed set (>60%). F_1 hybrids appear as vigorous as the F_1s from intraspecific crosses, but fertility tests have not been performed because of the extremely slow growth rate of *Labordia*. The intergeneric cross between one *Geniostoma* individual and three *Labordia* individuals was unsuccessful. *Labordia* species are distinct morphologically, ecologically, and geographically, but lack genetic barriers to prevent interbreeding. This suggests that physical and morphological separation has occurred more quickly than genetic isolation within the species of the genus *Labordia* because of the recency of colonization and/or rapid speciation.

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Constructive Postmodern Physics

PAUL D. MOUNTCASTLE[31]

As early as the 1930s, it was known that great difficulties stood in the way of unifying Einstein's 1905 theory of relativity with the newer quantum mechanics of Heisenberg. These difficulties seem surprising in light of the logical similarities between the two theories, yet they have not been satisfactorily resolved to this day. The postmodern view takes as elementary the concept of physical interaction, defined as the exchange of finite information between bodies. Here the path to quantum mechanical ideas is easy, whereas space and time require some work. A picture is presented of interaction independent of our usual space and time, and mathematical operators are discussed that recover those concepts in the limit appropriate to classical physics.

Isolation of ACC Synthase Gene from Papaya and Study of Its Expression during Fruit Ripening

KABI RAJ NEUPANE AND J. I. STILES[32]

Fruit ripening in papaya, like other climacteric fruit, is controlled by the plant growth regulator ethylene. The rate-limiting enzyme of the ethylene biosynthetic pathway is 1-amino cyclopropane-1-carboxylate synthase (ACC synthase). An approximately 718 bp putative ACC synthase fragment was obtained by reverse transcriptase polymerase chain reaction (RT-PCR) using synthetic oligonucleotide primers and mRNA from 30% yellow fruit. The RT-PCR product was used to screen a papaya cDNA library constructed from 30% yellow fruit. Sixteen independent positive clones were identified. One 1888 bp clone was fully sequenced, and two additional clones were partially sequenced. All three clones are identical in the coding region. Comparison of the sequence with other sequences present in the GenBank revealed that this clone was ACC synthase and contained 487 amino acid open reading frame. A genomic Southern blot of four varieties of papaya ('Sunrise', 'Sunset', 'Kapoho', and Breeding Line 356) digested with either *Eco*RI, *Hind*III, *Xho*I, or *Bgl*II showed no polymorphism. Further, it suggested that, unlike other plants, there is only one ACC synthase gene in papaya. Expression of ACC synthase during fruit ripening was examined by northern blotting of mRNA from seven ripening stages of 'Sunrise'. ACC synthase mRNA rises dramatically in the mesocarp of 20–70% yellow fruit as compared with earlier stages of development, but is almost totally abolished in 100% yellow fruits. In endocarp, expression is high in mature green fruit and decreases drastically by the time fruit are 70% yellow. This is consistent with fruit ripening proceeding from inside outward.

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Phototoxicity in a Coral Reef Flat Community

RITA L. PEACHEY[33]

The synergistic effect of polycyclic aromatic hydrocarbons (PAHs) and ultraviolet radiation (UVR), termed phototoxicity, was tested on coral reef flat organisms. Organisms from five animal phyla (Crustacea, Annelida, Mollusca, Porifera, and Cnidaria) were incubated in solutions of the PAHs anthracene or pyrene, at concentrations below the solubility of these PAHs in seawater, followed by exposure to UVR. Crustaceans, polychaetes, and some cnidarians were susceptible to phototoxicity at PAH concentrations and light intensities that can occur in their reef flat habitat. These concentrations of PAHs did not cause acute toxicity in the absense of UVR. Photo-induced toxicity of marine organisms was dependent on the concentration of PAH, intensity and wavelength of UVR, and taxonomic affinity and occurred at PAH concentrations three to four orders of magnitude below that reported for toxicity by PAH alone. Demonstration of phototoxicity in marine organisms using concentrations of PAHs within their aqueous solubility limits and radiation within the spectrum and intensity occurring in the reef flat habitat suggests that phototoxicity may be occurring in marine nearshore waters. Increases in PAH in nearshore waters as areas become more urbanized combined with a likely increase in ambient levels of solar UVR (due to ozone depletion) could lead to greater occurrence of phototoxic events. Differences in susceptibility of marine organisms to phototoxicity could have unexpected ecological consequences at the level of the community.

Biogeography of the Genus *Sargassum* (Phaeophyta) in the Pacific Basin: Current Status and Modern Revision[34]

NAOMI PHILLIPS[35]

Sargassum is a species-rich, taxonomically complex genus distributed in many of the world's oceans and is an ecological dominant in many tropical areas. Despite its importance, not much is understood about the biogeography or evolutionary history of *Sargassum*. This paper presents a modern synthesis of distribution records and ecological models for biogeography to build a foundation for addressing issues that relate to the distribution, evolution, and biogeography of *Sargassum* in the Pacific basin and Hawai'i, including examination of current taxonomic schemes for *Sargassum*; synthesis of distribution information leading to species numbers and a distribution map for subgenera; application of biogeographical models to interpret distribution, endemism, and diversity patterns for subgenera; and creation of a foundation to shape future questions about the evolution and phylogeny of Hawaiian *Sargassum*.

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[34] This research was supported by an AASERT fellowship, Office of Naval Research.

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Raised Hematocrit Levels in Males of Sexually Dichromatic Birds as a Secondary Sexual Character[36]

JOBY L. ROHRER[37]

Hematocrit levels have traditionally been considered species-specific characters. However, sexual differences may exist when activity of the sexes differs. Such differences may be most apparent during competition for mates. Hematocrit level was investigated among three sexually dichromatic (Hawai'i 'Ākepa, Common 'Amakihi, Hawai'i 'Elepaio) and two sexually monochromatic ('I'iwi, 'Apapane) passerine species in the same environment at 1900 m elevation. Samples were collected at times of the year when mating, nesting, and molting occur. Males and females within all species have similar lowest levels during molting. In monochromatic species, hematocrit levels are similar between the sexes throughout the year. However, males of sexually dichromatic species have higher hematocrit levels during the mating season. During those months, males have an increased level of activity associated with rigorous mating displays (Hawai'i 'Ākepa) and aggressive territorial interactions (Common 'Amakihi, Hawai'i 'Elepaio). During nesting, all males provide parental care, but only in the nonterritorial 'Ākepa did hematocrit levels decline to those of females. Hematocrit level appears to be adjusted in males to exercise physiology when sexually selected behaviors are the product of that physiology.

Spatial Settlement Patterns and Ontogenetic Habitat Shifts of the Tropical Marine Goby *Bathygobius coalensis* in Intertidal Zones[38]

DAVID J. SHAFER[39]

Most demersal marine fishes have complex life histories characterized by a planktonic larval stage followed by metamorphosis and settlement to the benthos. During settlement, certain spatial strategies may improve recruitment success and may be evident in population size distributions. Monthly size-frequency analyses of *B. coalensis* distributions were conducted from collections along a transect including high (upper range of tidal inundation), intermediate, and low intertidal areas at Sandy Beach, O'ahu, from January 1991 to December 1993. New recruits occupied refugia high along the shoreline, and juveniles and adults occupied middle and low intertidal regions, respectively. Initial settlement into shallow-water habitat, such as high intertidal areas, followed by ontogenetic shifts into the adult habitat may be an important mechanism to avoid predation or competition with older conspecifics. In addition, warmer daytime water temperatures, due to tidal isolation and exposure to hot air temperatures, may facilitate faster growth, whereas weaker flow regimes may facilitate retention of fishes. Shallow nearshore habitats may serve as important nursery areas for many marine species, but are often vulnerable to degradation and loss because of limited spatial extent and exposure to anthropogenic perturbation and urbanization.

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Somatotropic Activities of Homologous Tilapia Prolactin ($tPRL_{177}$) and Growth Hormone in the Tilapia, *Oreochromis mossambicus*[40]

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In teleosts, it is increasingly clear that growth hormone (GH) has growth-promoting effects on skeletal tissue through hepatic production of insulinlike growth factor-I (IGF-I). Somatotropic actions of PRL have been reported in higher vertebrates, but are less well established in teleosts. We examined the effects of injections of homologous PRLs ($tPRL_{177}$ and $tPRL_{188}$) and GH on [^{35}S]-sulfate (extracellular matrix synthesis) and [^{3}H]-thymidine (DNA synthesis) incorporation by branchial cartilage explants, in vitro, and on IGF-I and IGF-II mRNA levels in the liver of the tilapia. GH and $tPRL_{177}$ stimulated sulfate uptake in a dose-related manner. Thymidine incorporation was stimulated by $tPRL_{177}$. $tPRL_{188}$ was without effect. Consistent with the somatotropic actions of GH and IGFs in vertebrates, GH elevated IGF-I mRNA levels in the liver. Liver IGF-II mRNA levels were also elevated by GH. $tPRL_{177}$ elevated liver IGF-I and IGF-II mRNA levels. High-affinity, low-capacity binding sites for GH are present in tilapia liver. $tPRL_{177}$ binds to these sites with a lower affinity than GH, but elevations in plasma PRL levels in freshwater-adapted tilapia may provide for sufficient levels of this hormone to act as a competitive ligand for GH receptors. Collectively, these findings suggest that the growth-promoting actions of $tPRL_{177}$ may be achieved through its binding to GH receptors.

Lack's Clutch Size Hypothesis: An Examination of the Evidence Using Meta-Analysis[46]

ERIC A. VANDERWERF[47]

David Lack hypothesized that clutch size in birds has evolved toward that which produces the most surviving offspring, and that the upper limit to clutch size is determined by ability of parents to provide food for nestlings. This hypothesis has frequently been tested by experimentally increasing brood size and measuring fledging success. Results of previous studies have been inconsistent. Meta-analysis is a statistical method of integrating results from a number of studies on a subject. I used meta-analysis of 42 independent brood-enlargement studies on a variety of bird species. Cumulative evidence did not support Lack's hypothesis. Significantly more fledglings were produced in enlarged broods than in normal-sized broods, indicating that parents could raise more young than they had eggs. The standardized treatment effect of brood enlargement across all studies was a mean increase of 0.55 stan-

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dard deviations in the number of young produced. I also examined differences in methodology and species studied as potential confounding factors and explanations for conflicting results. Studies more than 1 yr long were more likely to show food limitation, suggesting that clutch size is optimized over a period longer than 1 yr and that annual variation is important. Species with altricial young were also more likely to show food limitation, reflecting the greater demands placed on parents. Latitude and date of study, degree of brood enlargement, validity of study, and annual adult survival did not affect results.

Biology of the Galápagos Shark in Hawai'i

BRADLEY M. WETHERBEE,[48] GERALD L. CROW,[49] AND CHRISTOPHER G. LOWE[48]

Catch records from the Hawai'i Cooperative Shark Research and Control Program (1967–1969) were examined, and other available data on the Galápagos shark, *Carcharhinus galapagensis*, were analyzed. A total of 304 Galápagos sharks was caught. More female sharks were caught than males, and the catch distribution was skewed geographically and by depth. On the island of O'ahu, the highest catch rates occurred along the north and south coasts. High catch rates also occurred near points of land, where longshore currents converge. Average depth of capture was greater for juveniles (45.1 m) and mature males (60.2 m) than for subadults (38.8 m) and mature female sharks (34.2 m). Males reached maturity at between 205 and 239 cm total length, and females at between 215 and 245 cm. Litter size ranged from 4 to 16 pups, with an average of 8.7. Size at birth was just over 80 cm. Mating and parturition appear to occur early in the year, and the gestation period is estimated at ca. 12 months. Stomach contents consisted mainly of teleosts and benthic prey. Changes in diet occurred as sharks increased in size. The proportion of teleosts decreased, and more elasmobranchs were eaten. Dietary diversity also increased as sharks became larger.

Molecular Characterization of the White Eye Gene of Oriental Fruit Fly, *Bactrocera dorsalis* (Diptera: Tephritidae)[50]

XIAOWEN ZHENG AND STEPHEN SAUL[51]

The oriental fruit fly is an important agricultural pest in the Pacific basin and threatens the U.S. mainland. A species-specific genetic transformation system is a key tool of the pest control program. We have cloned and sequenced the white eye (*we*) gene, which is required for the eye pigmentation of the fly and is a good potential transformation marker gene. The probable exon-intron structure of the gene has been predicted. There is over 90% protein sequence similarity among the *we* genes of *Bactrocera dorsalis, Lucilia cuprina*, and *Drosophila melanogaster*. The oriental fruit fly *we* gene has one extra intron located in exon four, and prefers A, T base in the third position of the codon compared with that of *Drosophila melanogaster*.

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Divalent Cation Transport Processes in the Pyloric Ceca of a Sea Star, *Pycnopodia helianthoides*[52]

ZHENPENG ZHUANG[53]

$^{45}Ca^{2+}$ uptake by brush border membrane vesicles of sea star pyloric ceca was stimulated by an outwardly directed H^+ gradient, and this stimulation was enhanced by the simultaneous presence of an induced membrane potential (inside negative; K^+/ valinomycin). External addition of amiloride (competitive inhibitor; $K_i = 660$ μM), Na^+, and a monoclonal antibody produced to proteins associated with the lobster (*Homarus americanus*) electrogenic 2 $Na^+/1H^+$ antiporter, all inhibited approximately half of the proton gradient-stimulated $^{45}Ca^{2+}$ uptake. These results suggested that $^{45}Ca^{2+}$ might be transported by the electrogenic antiporter and also implied a molecularly similar epitope in the electrogenic antiporter from the two animals. Carrier-mediated Ca influx by amiloride-sensitive (AS) and amiloride-insensitive (AIS) systems displayed the following kinetic constants: (AS) $K_t = 66 \pm 2$ μM; $J_{max} = 0.173 \pm 0.002$ pmol/μg protein per 8 sec; (AIS) $K_t = 18 \pm 0.3$ μM; $J_{max} = 0.100 \pm 0.001$ pmol/μg protein per 8 sec. Zn^{2+} was a mixed inhibitor of Ca influx by carrier-mediated transport, displaying a K_i of 920 μM. Evidence from an equilibrium-shift experiment, based on thermodynamics of coupled transport processes, suggested that divalent (Ca^{2+} and Zn^{2+}) cations might be able to enter pyloric cecal cells through a common carrier-mediated transport protein.

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